3.39 OPTICAL/MANUAL TRACKING DESCRIPTION

Many of the weapon systems modeled in *RADGUNS* have optical tracking systems. Optical tracking is the principle tracking method for systems that do not have radar. For systems that do have radar, optical tracking modes may be selected by the operator when the radar is either not functioning or is being jammed, or when the operator simply does not want the system to radiate. Optical tracking modes are categorized in *RADGUNS* by the type of prediction used for the firing solution. Some systems use a fire control computer to generate a firing solution (an OPFCC track/prediction type in *RADGUNS*). These systems use direct-view optics (cross-hairs) to generate angle information and a laser range finder or radar for range information. Other systems rely on optics only or operator estimates for prediction (an OPEST track/prediction type). *RADGUNS* models optical-mechanical computing sights, optical-lead computing sights, optical-speed rings, and human prediction of lead and superelevation with no mechanical aids. The program selects the appropriate track mode for the weapon system selected. This analysis investigates the sensitivity of the direct-view optics in angle, radar tracking in range, FCC prediction OPFCC option and the optical-speed rings OPEST option to various inputs.

Subroutine OPTRAK simulates the operator's attempt to keep the cross-hairs of a telescope aligned with the center of a target over time. Operator characteristics that affect this function are operator response time and the minimum error that the operator can detect. These characteristics are set based on a user input operator skill level. The minimum detectable error increases as the angular velocity of the telescope increases.

Subroutine SPDRNG simulates full optical tracking with speed rings. Angle tracking is performed by subroutine OPTRAK (the operator's attempt to position the nose of the target on the ring corresponding to the target aspect is modeled in exactly the same manner as the operator's attempt to position the cross-hairs of the telescope on the center of the target). The time of flight to tactical range is used to compute an initial lead angle for firing at the target. Operator estimates of range are used to superelevate the target on the scope. It is assumed that the operator can estimate range to the nearest 250 meters at ranges of less than 2500 meters, and to 500 meters at ranges of up to 5000 meters. Once the guns have been fired, the operator uses tracer feedback to adjust the telescope/gun position if a large miss distance is observed.

TABLE 3.39-1. Data Items Required.

Data Item		Accuracy	Sample Rate	Comments
12.2.1	Tracking azimuth	±0.1 deg	10 Hz	OPFCC, OPEST
12.2.2	Tracking elevation	±0.1 deg	10 Hz	OPFCC, OPEST
12.2.3	Radar Range	±5 m	10 Hz	OPFCC only
12.2.4	Operator range est.	±20 m	10 Hz	OPEST only

3.39.1 Objectives and Procedures

Optical tracking errors are sensitive to changes in target speed and operator skill level. *RADGUNS* was exercised with the following input conditions:

a. Model Mode: SNGL/OPFCC/OPEST
b. Target Presented Area: 10 m^2
c. Target RCS: 10 dBsm
d. Target Speed: 50, 150, 300 m/s
e. Flight Path: LINEAR
f. Target Offset/Altitude: 200/300 m
g. Radar type: RAD1
h. Guns: Disabled
i. Operator Skill Level: Low, medium, high
j. Scenario Termination: Target out of gun range and receding
k. Output: Azimuth, elevation, and range tracking errors

3.39.2 Results

Optical Cross-Hairs (OPFCC)

Figures 3.39-1 through 3.39-3 show the effect of target speed on azimuth, elevation, and range tracking errors while in the optical cross-hair tracking (OPFCC) mode. A medium skill level was used in all cases. The model assumes that there is a minimum angular error that the operator can detect and a time delay in the operator's reaction to perceived errors. This causes the oscillation in tracking errors as shown. An increase in target speed causes an increase in tracking errors (most noticeable as the target approaches crossover) due to the inability of the operator to keep up with the target. Range information is provided by the radar for the OPFCC optical mode. These errors also increase with target speed (see Section 3.28, Range Track). During the time segments shown the target is within gun range and is being tracked by the system.

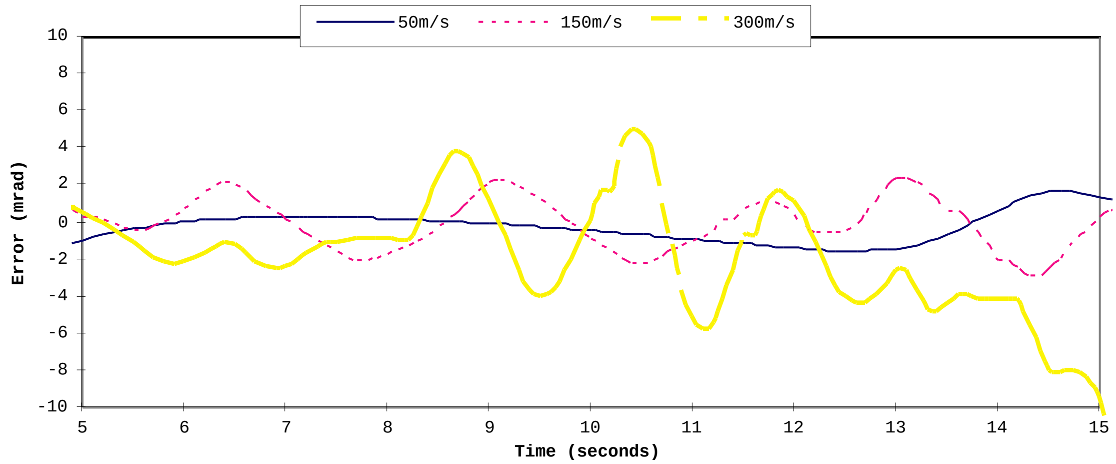

FIGURE 3.39-1. Azimuth Errors, Optical Cross-Hair Tracking.

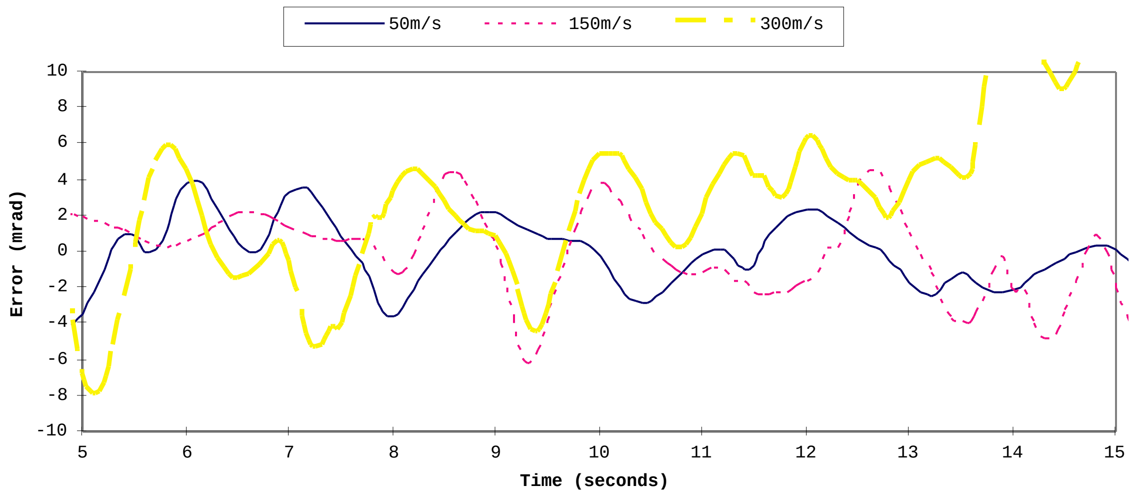

FIGURE 3.39-2. Elevation Errors, Optical Cross-Hair Tracking.

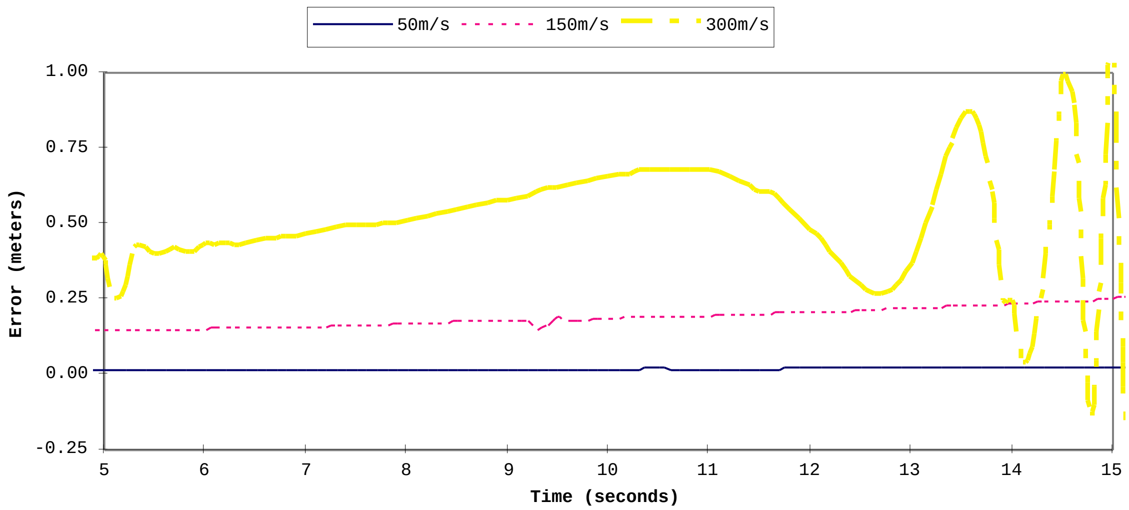

FIGURE 3.39-3. Range Error, Optical Cross-Hair Tracking.

Figures 3.39-4 through 3.39-6 show the effect of operator skill level (as defined in section 2.6.1.6 of Volume 1 of the *RADGUNS Antiaircraft Artillery Simulation User Manual)* on azimuth, elevation, and range tracking errors for optical cross-hair tracking of a 150m/s target. As expected, as the operator skill level increases, the generated errors decrease.

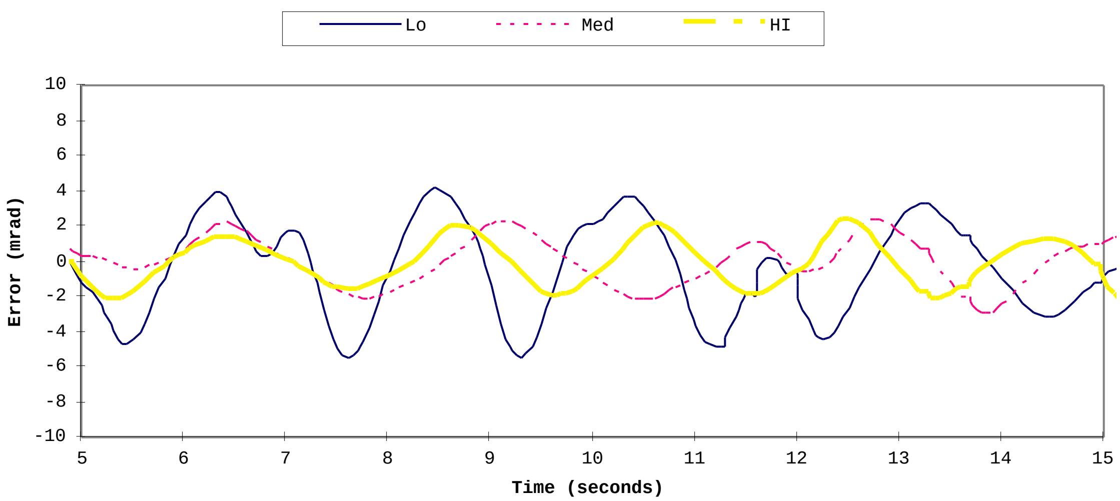

FIGURE 3.39-4. Azimuth Errors, Optical Cross-Hair Tracking.

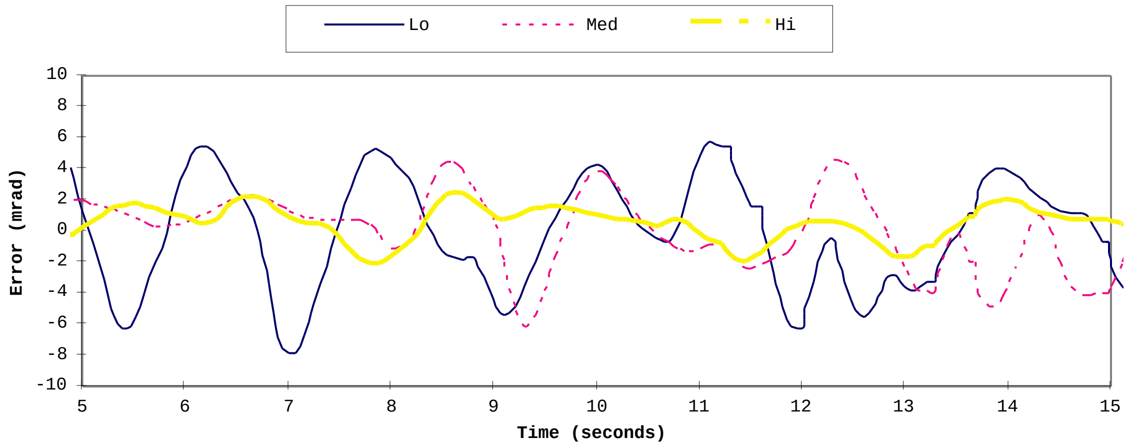

FIGURE 3.39-5. Elevation Errors, Optical Cross-Hair Tracking.

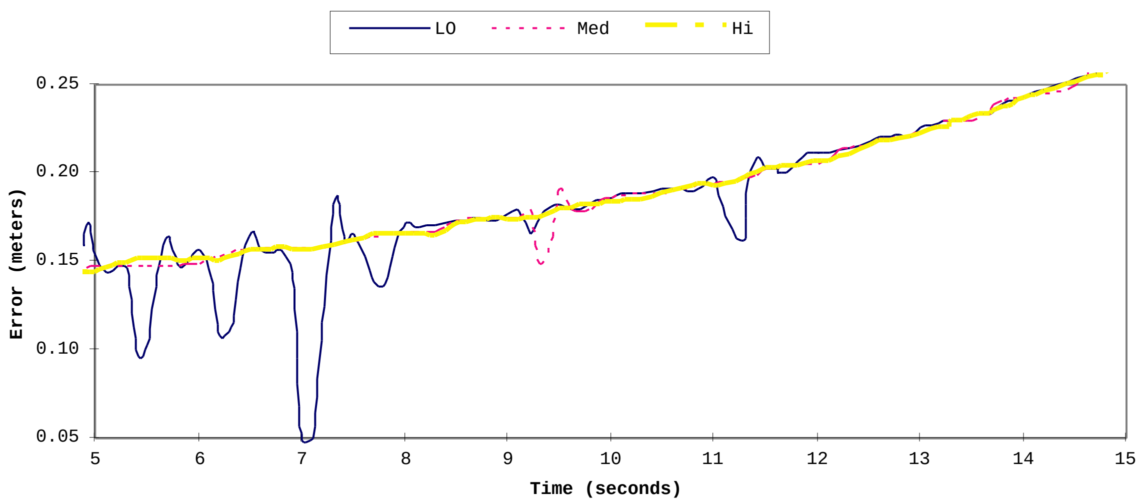

FIGURE 3.39-6. Range Errors, Optical Cross-Hair Tracking.

Optical Speed Rings (OPEST)

For optical tracking with speed rings, the operator's attempt to position the nose of the target on the ring corresponding to the target aspect is modeled in exactly the same manner as the operator's attempt to position the cross-hairs of the telescope on the center of the target in optical cross-hair tracking. For optical tracking with speed rings, gun lead angle is determined by the position of the target on the scope (velocity and aspect). Operator estimates of range are used to superelevate the guns. It is assumed that the operator can estimate range to the nearest 250 meters at ranges of less than 2500 meters, and 500 meters at ranges up to 5000 meters. Figures 3.39-7 through 3.39-9 show the effect of target speed on azimuth, elevation, and range tracking errors when using optical tracking with speed rings. A medium skill level was used in all cases.

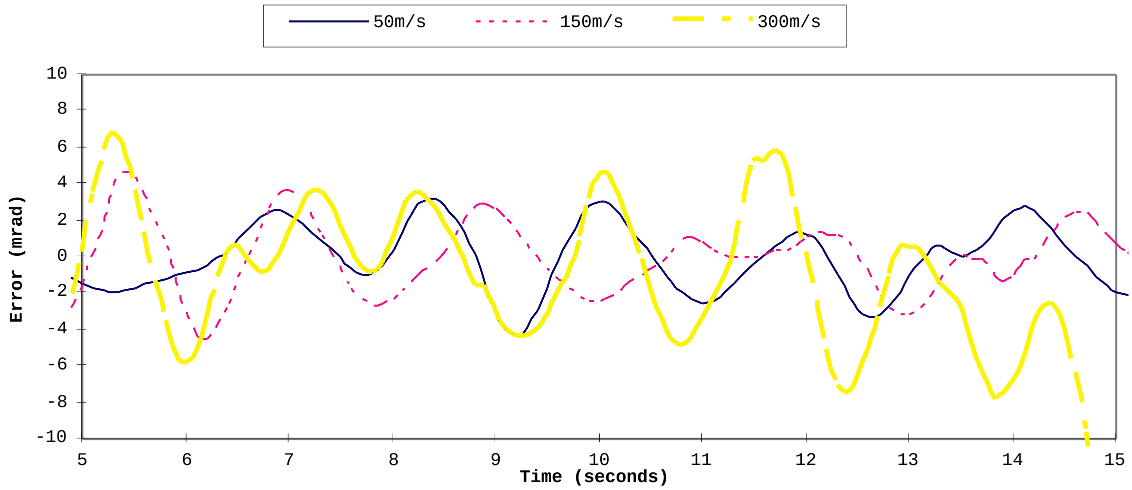

FIGURE 3.39-7. Azimuth Error, Optical Speed Ring Tracking.

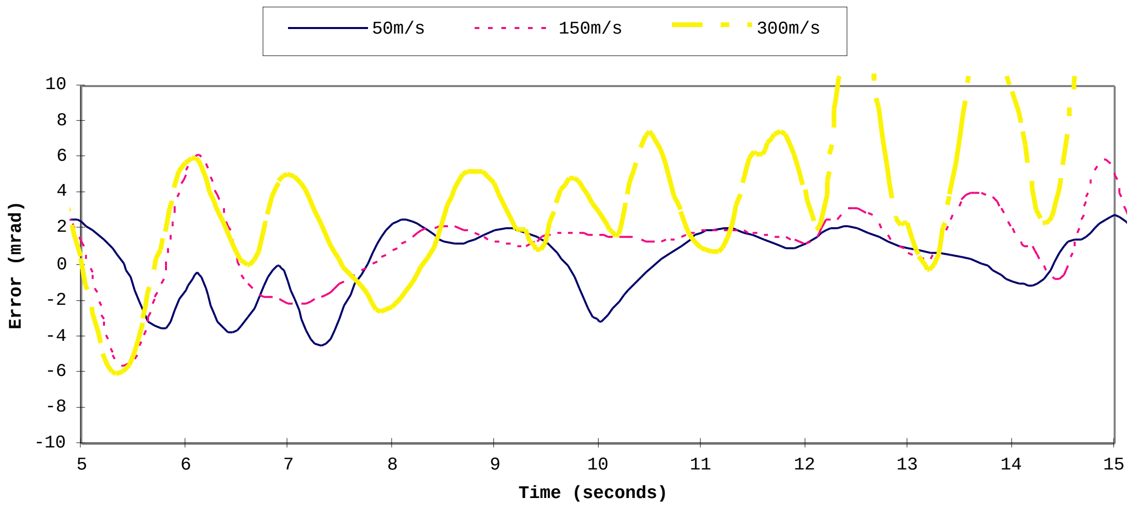

FIGURE 3.39-8. Elevation Error, Optical Speed Ring Tracking.

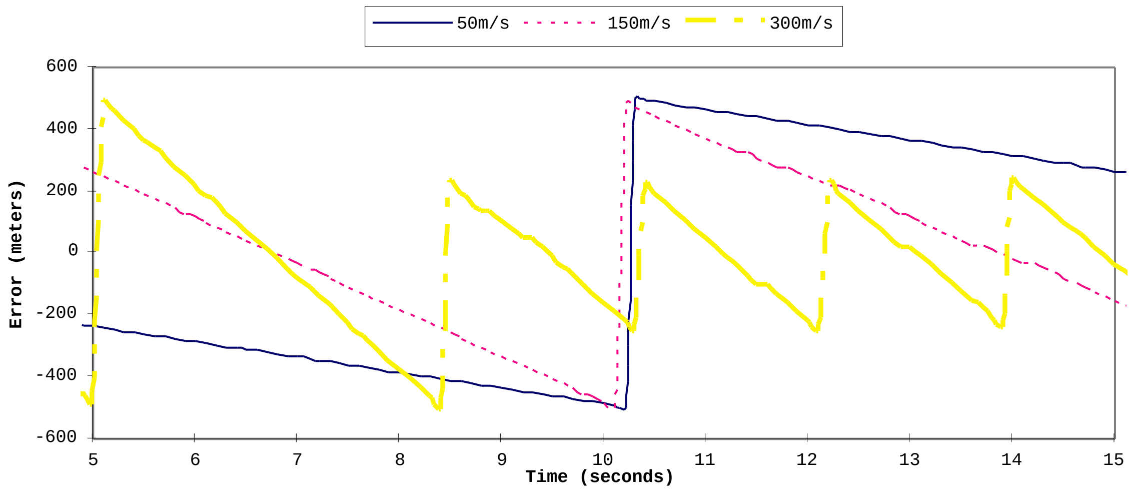

FIGURE 3.39-9. Range Error, Optical Speed Ring Tracking.

As shown previously, an increase in target velocity causes an increase in angle error. Range errors, however, are determined based on target range. For the slow moving targets, the aircraft are outside of 2500 meters, and the range is predicted to within 500 meters. The fast moving target moves to within 2500 meters between 8 and 9 seconds, and the errors fall to within 250 meters.

Figures 3.39-10 through 3.39-12 show the effect of operator skill level on azimuth, elevation, and range tracking errors for optical speed ring tracking of a 150m/s target. A lower operator skill level yields an increase in tracking errors as the operator attempts to position the nose of the target on the ring corresponding to the target aspect. Because range tracking errors are a function of target range only, range errors are insensitive to operator skill level.

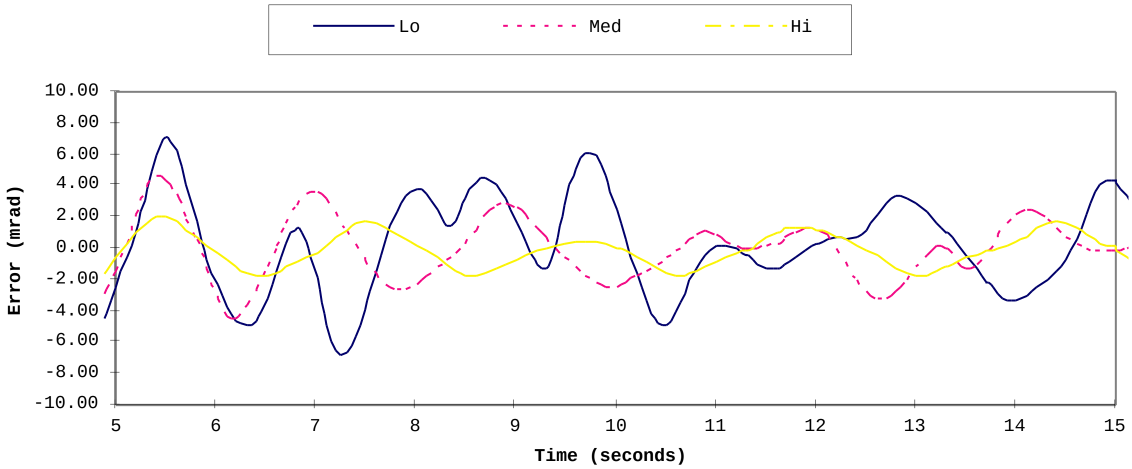

FIGURE 3.39-10. Azimuth Errors, Optical Speed Ring Tracking.

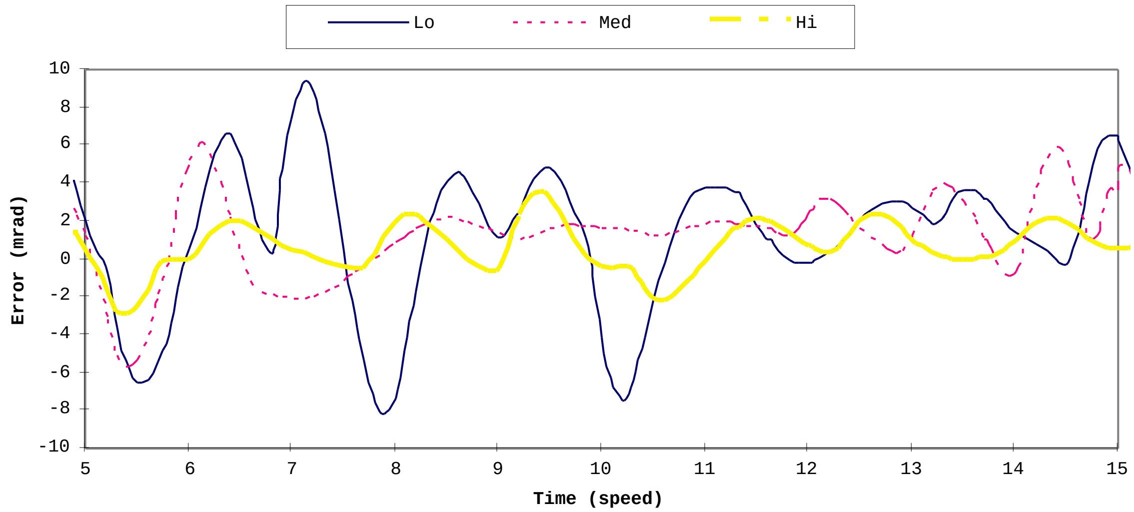

FIGURE 3.39-11. Elevation Errors, Optical Speed Ring Tracking.

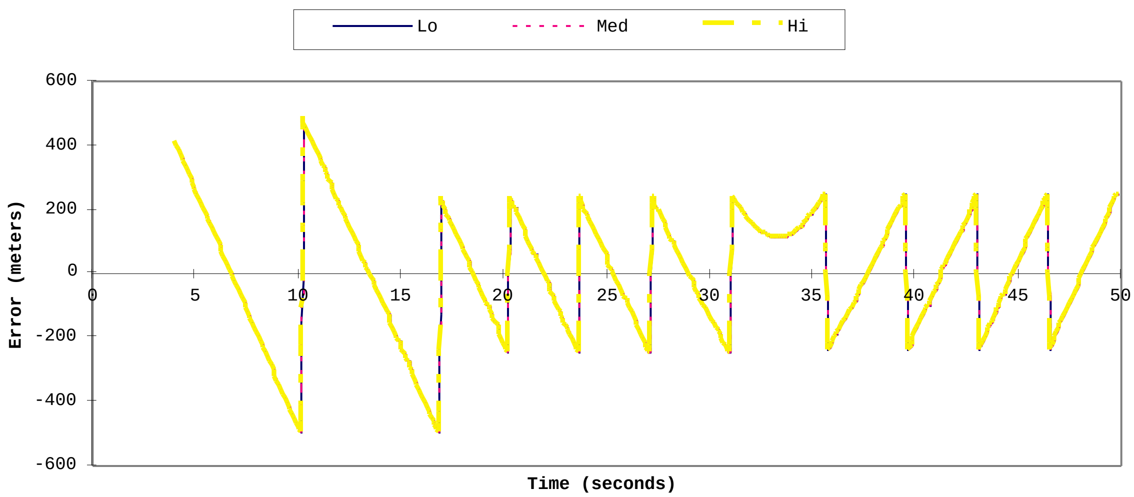

FIGURE 3.39-12. Range Errors, Optical Speed Ring Tracking.

3.39.3 Conclusion

The OPFCC track/prediction type for this system uses crosshair tracking for angle information and the radar for range information. The angle tracker is moderately sensitive to target speed. As target speed increases, the angle errors increase. The radar range tracker is also moderately sensitive to target speed, although the errors generated are quite small in all the observed cases.

The OPEST track/prediction type for this system is full optical tracking with speed rings. The crosshair tracker model is used to generate angle errors, and the same sensitivities apply. Range errors, however, are a function of target range only, thus range errors are insensitive to both target speed and operator skill level.